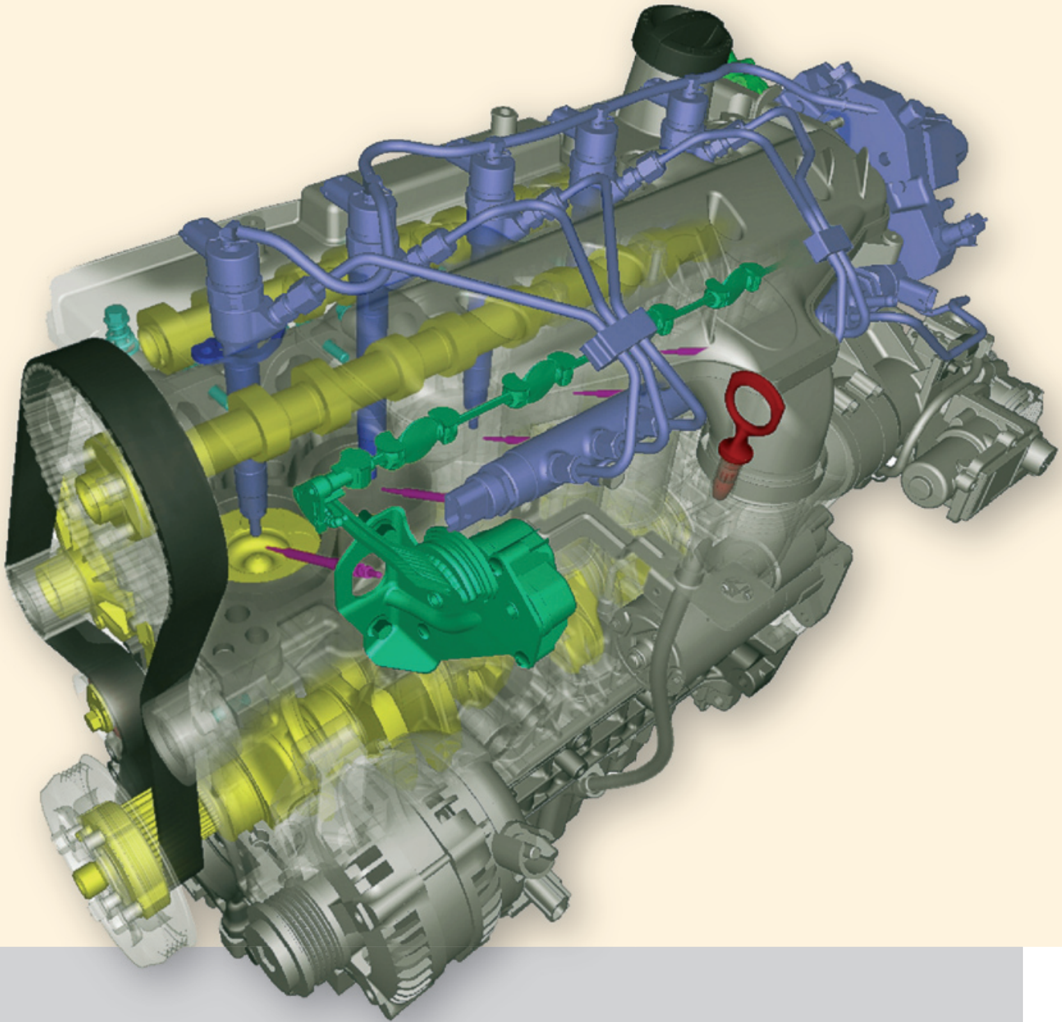


VOLVO

NEW CAR FEATURES 0520

VOLVO
for life

THEORETICAL SESSIONS

Foreword

Content of NCF 0520

For a comprehensive presentation of the content of NCF 0446, see the booklet:
NEW CAR FEATURES 0520
TECHNICAL PRESENTATION
S40, V50, S60, V70, XC70, S80, XC90

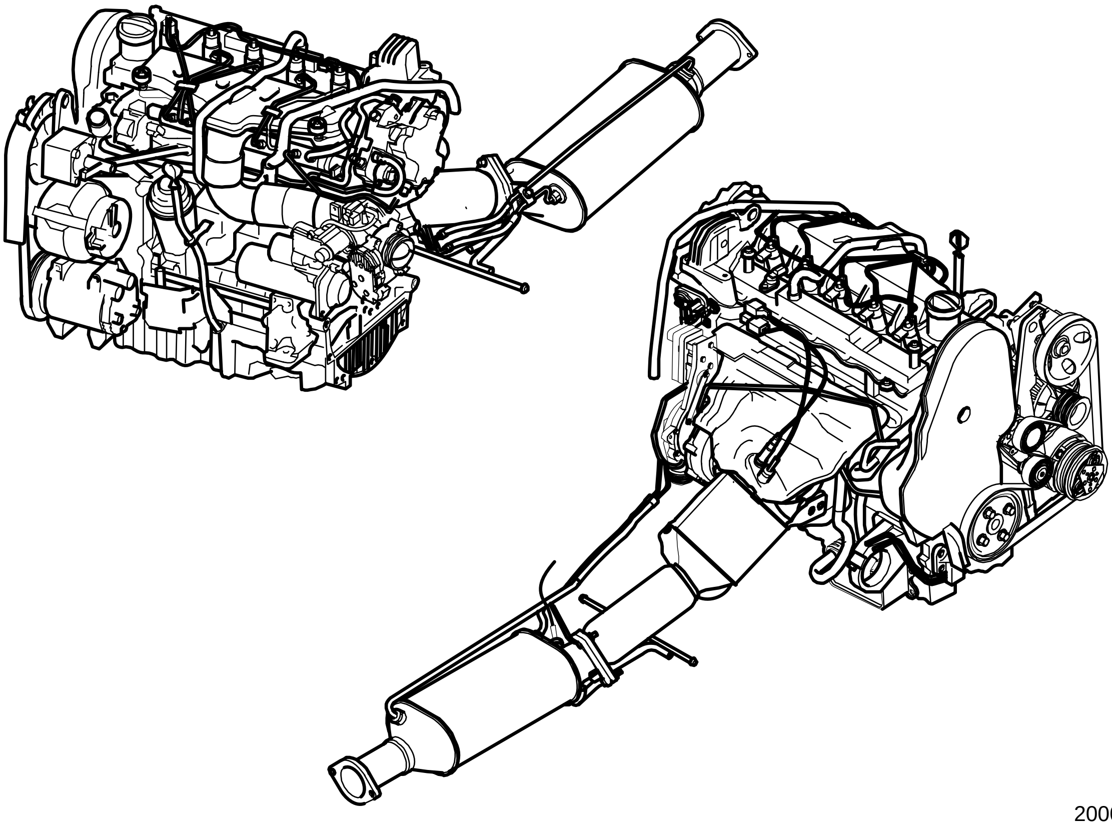
The booklet is available for download from Volvo Cars Leaning Center (WBT = Web Based Training).

Content of this booklet

This booklet is an in-depth look at the major new features of NCF 0520 - the innovations that require additional explanation beyond what is found in the comprehensive presentation.

The theoretical examination is supplemented with a practical booklet.

Contents



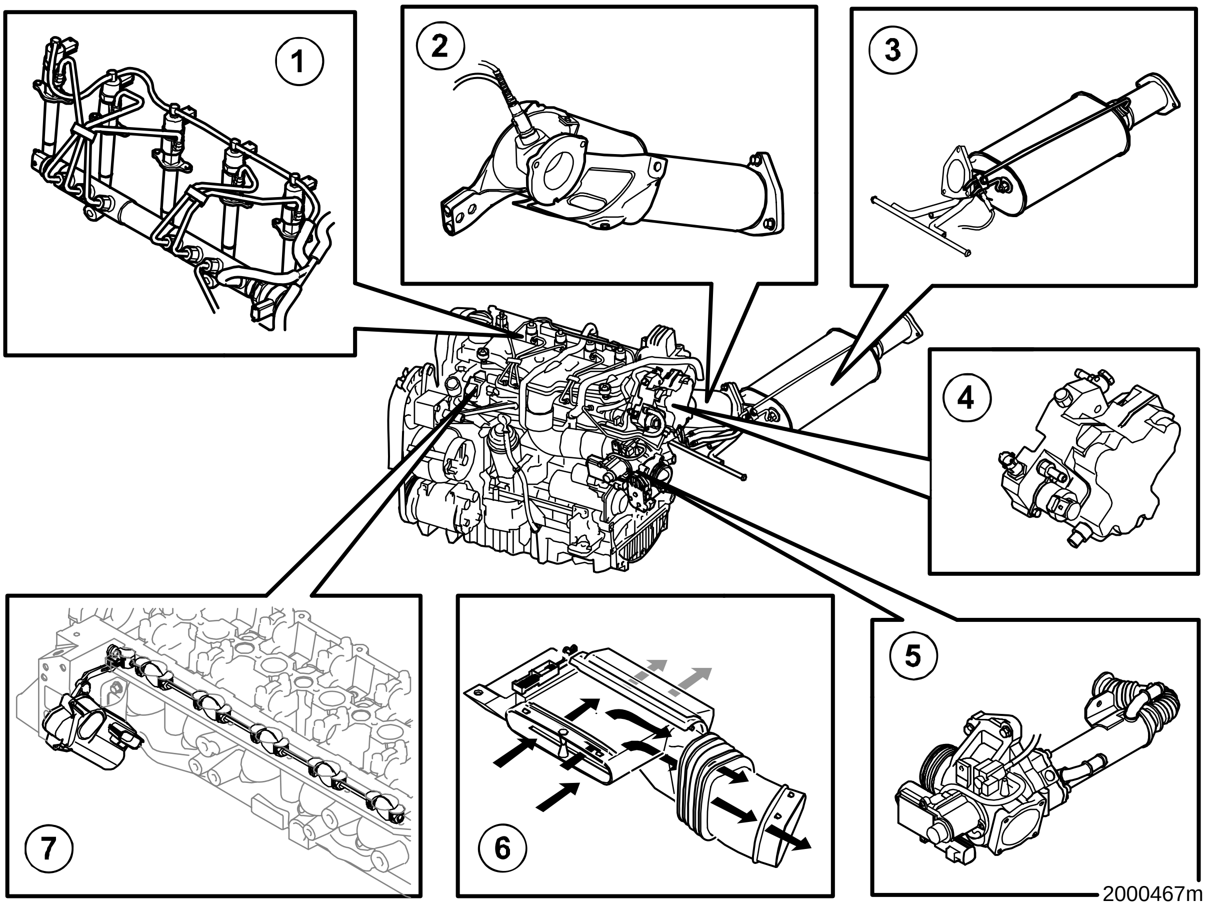
Engine D5244T4/T5/T6/T7

General

Engine variants D5244T4/T5/T6/T7 introduced from and including ÄT0520. Design is based on D5244T/T2.

- Engine variants D5244T4/T5/T6/T7 are identical apart from performance. Performance is determined by the software in the ECM.
- All engine variants comply with the emission requirements of EURO4.
- The engine is only introduced with manual gearbox. Automatic gearbox will be introduced later.
- Engine management system Bosch EDC16.
- Particle filter cDPF (catalyst Diesel Particulate Filter). No additives required to reach the required temperature for the regeneration process.
- Compression lowered from 18.0:1 to 17.3:1. Results in improved filling with improved performance and lower emissions.
- Coolant heated crankcase ventilation. PTC element discontinued.
- Oil grade ACEA A5/B5. Viscosity 0W-30.
- Service interval 30,000 km or 1 year. NOTE: depending on market.
- Note that for the S80 the "old" D5244T/T2 remains.

Notes



1	Injectors with pipe and fuel rail	5	Exhaust gas recirculation (EGR) unit
2	Catalytic converter	6	Air inlet housing
3	cDPF (catalyst Diesel Particulate Filter)	7	Swirl throttle
4	High pressure pump		

Modifications compared with the D5244T/T2

The following modifications have been made amongst others in order to comply with the emission requirements of EURO4:

- The injectors (1) have 7 holes (previously 5 holes) which results in improved combustion and consequently reduced emissions.
- Catalytic converter (2) with greater capacity. Reduces HC and CO emissions.
- cDPF (catalyst Diesel Particulate Filter), (3) where particles are stored and combusted. The filter also works as an oxidation catalytic converter.
- High pressure pump (4). A higher injection pressure is used in general during the entire loading and engine speed range. Results in an improved fuel/air mixture which results in more efficient combustion.
  NOTE: Max. pressure of 1600 bar is unchanged.
- Exhaust gas recirculation (EGR) (5) is used to a greater extent than previously. This reduces NOx emissions.

- An air inlet housing (6) with shutter and thermostat is located on the duct for the incoming external air. The shutter is designed to prevent snow entering with the intake air. If snow does enter with the air flow then there is a risk that the air filter will become clogged resulting in impaired performance. By opening the shutter at low outside temperatures the snow is separated from the air by means of its weight and viscosity. The snow continues straight back toward the engine while the air turns off and reaches the air filter.
  A wax thermostat regulates the position of the shutter depending on the outside temperature. At an outside temperature of between approx. +5 - +10°C the shutter starts to open gradually, and at approx. +5 - +/-0°C it is fully open. From being fully closed to fully open can take up to a couple of minutes.
  If the shutter jams in open position then impaired engine performance at "take off" can arise at high outside temperatures. This is because the hot air is directed the "back way" from the engine compartment to the engine (and the combustion chamber).
  In addition, if the shutter jams open, the cooling capacity can be impaired at high outside temperatures. This is because a certain amount of air passes by the side of the radiator instead of through it.
- Variable throttle, a so-called "swirl throttle" (7), located in the cylinder head's tangential ducts. Regulates the air distribution between the tangential and swirl ducts to the cylinders. Proportionately more air through the swirl ducts results in a more powerful swirl formation which improves the combustion process.

Engine cooling fan

Brushless fan (same as has been used for turbocharged engines in the S60, V70, S80 and XC90 etc.), with the following data:

- Output 600W.
- Number of fan blades: 13.
- Higher efficiency compared with fan with brushes.
- Control module EFCM (Electronic Fan Control Module) is integrated in the engine.
- Noise characteristics differ compared with a fan with brushes. At certain speeds noise may arise that could be interpreted as a fault.
  In the event of replacement, always make sure that the fan is actually affected by a fault.
- Fan control takes place in four fixed stages based primarily on AC pressure and coolant temperature.
- By modulating the PWM signals EFCM can advise ECM on the status of the fan and any faults.

Afterrun

The cooling fan is activated for a certain time after the engine has been switched off in order to protect various engine components from overheating.
Fan activation time and fan speed are dependent on coolant temperature and driving style (engine load) when the engine is switched off. Afterrun takes place as follows:

- Initially a high speed is used, following which the speed is lowered in stages. There are three "variants".
- When stage 4 (top fan speed) is used the afterrun initially continues for 360 seconds.
  When stage 3 (intermediate speed) is used the afterrun initially continues for 255 seconds.
  When stage 2 (next lowest speed) is used the afterrun initially continues for 150 seconds.

Special cases

To prevent boiling (and thereby noise) in the AC system the cooling fan is always activated if the AC compressor is engaged when vehicle speed falls below 25 km/h. The fan is then always activated for 120 seconds in stage 1 (if "normal" cooling does not require a higher speed).
If the engine is switched off this request ceases to apply.

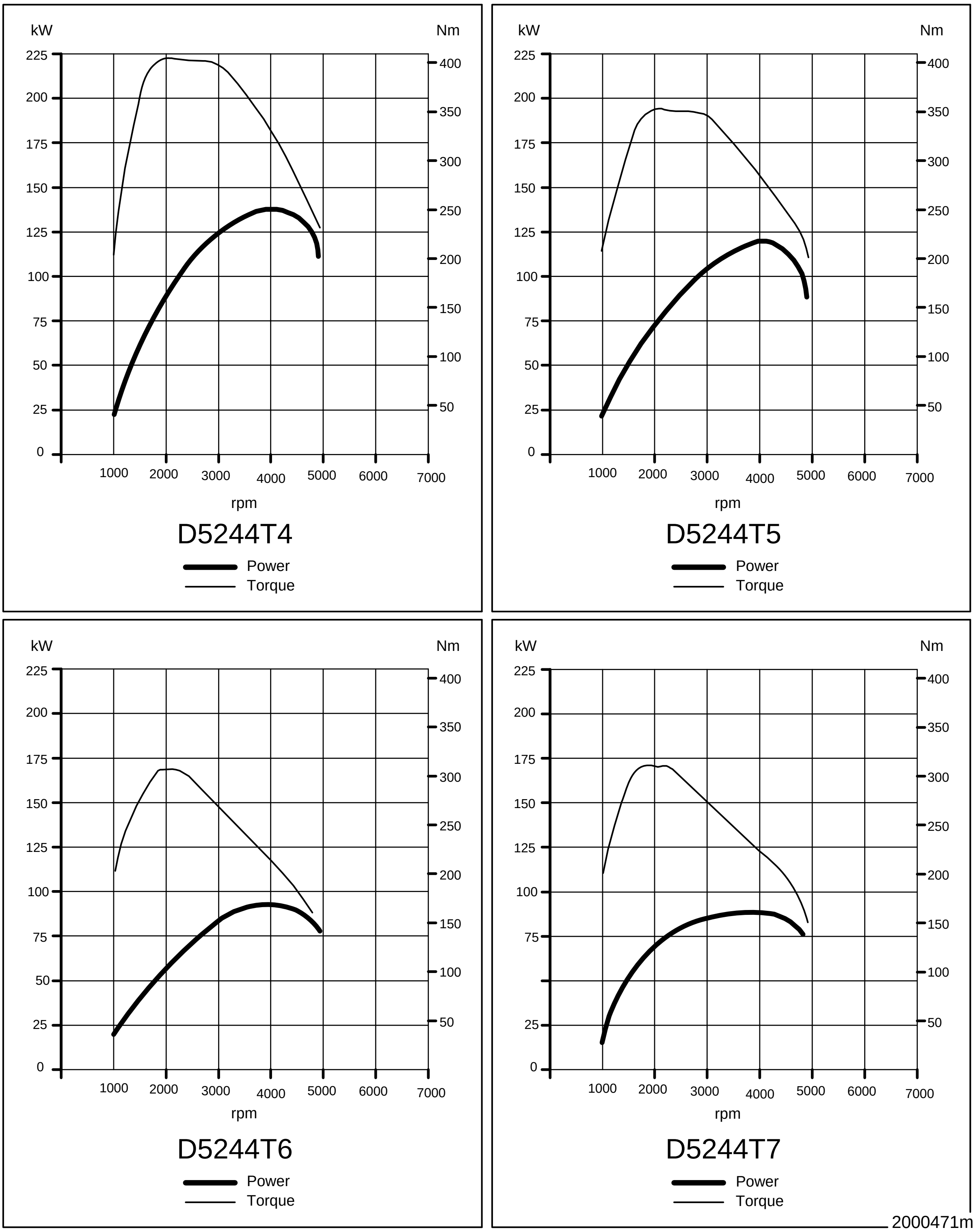
A protection system for the fan unit requires that when the fan has started up it must be activated for at least 90 seconds.

A consequence of this is that if the car is started in a workshop for example (which of course is equivalent to a vehicle speed of less than 25 km/h) and the AC compressor is on then the cooling fan will start up.
If the engine is then stopped after 45 seconds for example then the fan will operate for a further 45 seconds to fulfil the conditions.

These functions apply to all brushless fans immediately from when they were introduced.

Notes

Specifications



XC90

Engine	D5244T4
Output@4000 rpm	136 kW, 185 hp
Torque	400 Nm @ 2000 - 2750 rpm
Gearbox/gear ratio final drive	M66E/4.79
Acceleration 0-100 km/h	10.9 s
Acceleration 0-60 mph	10.3 s
Top speed	195 km/h, 121 mph
Fuel consumption, EU COMB, L/km	5 passengers = 8.2, 7 passengers = 8.3
CO_2, g/km	5 passengers = 217, 7 passengers = 219
Compression	17,3:1
Idling speed	700 rpm
Maximum engine speed	4600 rpm
Cetane	48 minimum

S60

Engine	D5244T4	D5244T5	D5244T6	D5244T7
Output@4000 rpm	136 kW 185 hp	120 kW 163 hp	90 kW 122 hp	92 kW 126 hp
Torque	400 Nm @ 2000 - 2750 rpm	340 Nm @ 1750 - 2750 rpm	300 Nm @ 1750 - 2250 rpm	300 Nm @ 1750 - 2250 rpm
Acceleration 0-100 km/h	8.2 s	9.2 s	11.9 s	11.9 s
Acceleration 0-60 mph	7.6 s	8.9 s	11.3 s	11.3 s
Top speed	230 km/h, 143 mph	210 km/h, 130 mph	200 km/h, 124 mph	200 km/h, 124 mph
Gearbox/gear ratio final drive	M66D/4.00	M56L2/3.77 M66D/4.00	M56L2/3.77	M56L2/3.77
Fuel consumption, EU COMB, L/100 km	6,6	M56L2/6.4 M66D/6.6	6,4	6,4
CO_2, g/km	174	M56L2/169 M66D/174	169	169
Compression	17,3:1			
Idling speed	700 rpm			
Maximum engine speed	4600 rpm			
Cetane	48 minimum			

V70

<table>
<tr><td colspan="2">Engine</td><td>D5244T4</td><td>D5244T5</td><td>D5244T6</td><td>D5244T7</td></tr>
<tr><td colspan="2">Output @ 4000 rpm</td><td>136 kW
185 hp</td><td>120 kW
163 hp</td><td>90 kW
122 hp</td><td>92 kW
126 hp</td></tr>
<tr><td colspan="2">Torque</td><td>400 Nm
@
2000 - 2750 rpm</td><td>340 Nm
@
1750 - 2750 rpm</td><td>300 Nm
@
1750 - 2250 rpm</td><td>300 Nm
@
1750 - 2250 rpm</td></tr>
<tr><td colspan="2">Acceleration 0-100 km/h</td><td>8.2 s</td><td>9.2 s</td><td>11.9 s</td><td>11.9 s</td></tr>
<tr><td colspan="2">Acceleration 0-60 mph</td><td>7.6 s</td><td>8.9 s</td><td>11.3 s</td><td>11.3 s</td></tr>
<tr><td rowspan="4">Top speed</td><td>2WD,
M66D</td><td>225 km/h,
140 mph</td><td>210 km/h,
130 mph</td><td>NA</td><td>NA</td></tr>
<tr><td>4WD;
M66E</td><td>215 km/h,
134 mph</td><td>NA</td><td>NA</td><td>NA</td></tr>
<tr><td>XC70,
M66E</td><td>210 km/h,
130 mph</td><td>NA</td><td>NA</td><td>NA</td></tr>
<tr><td>2WD,
M56L2</td><td>NA</td><td>210 km/h,
130 mph</td><td>200 km/h,
124 mph</td><td>200 km/h,
124 mph</td></tr>
<tr><td colspan="2" rowspan="3">Gearbox/gear ratio final drive</td><td>2WD,
M66D/4.00</td><td>M66D/4.00</td><td rowspan="3">M56L2/3.77</td><td rowspan="3">M56L2/3.77</td></tr>
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M66E/4.00</td><td rowspan="2">M56L2/3.77</td></tr>
<tr><td>XC70,
M66E/4.53</td></tr>
<tr><td colspan="2" rowspan="3">Fuel consumption,
EU COMB, L/100 km</td><td>2WD,
M66D/6.8</td><td>M66D/6.8</td><td rowspan="3">M56L2/6.5</td><td rowspan="3">M56L2/6.5</td></tr>
<tr><td>4WD,
M66E/7.3</td><td rowspan="2">M56L2/6.6</td></tr>
<tr><td>XC70,
M66E/7.6</td></tr>
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M66D/179</td><td>M66D/179</td><td rowspan="3">172</td><td rowspan="3">172</td></tr>
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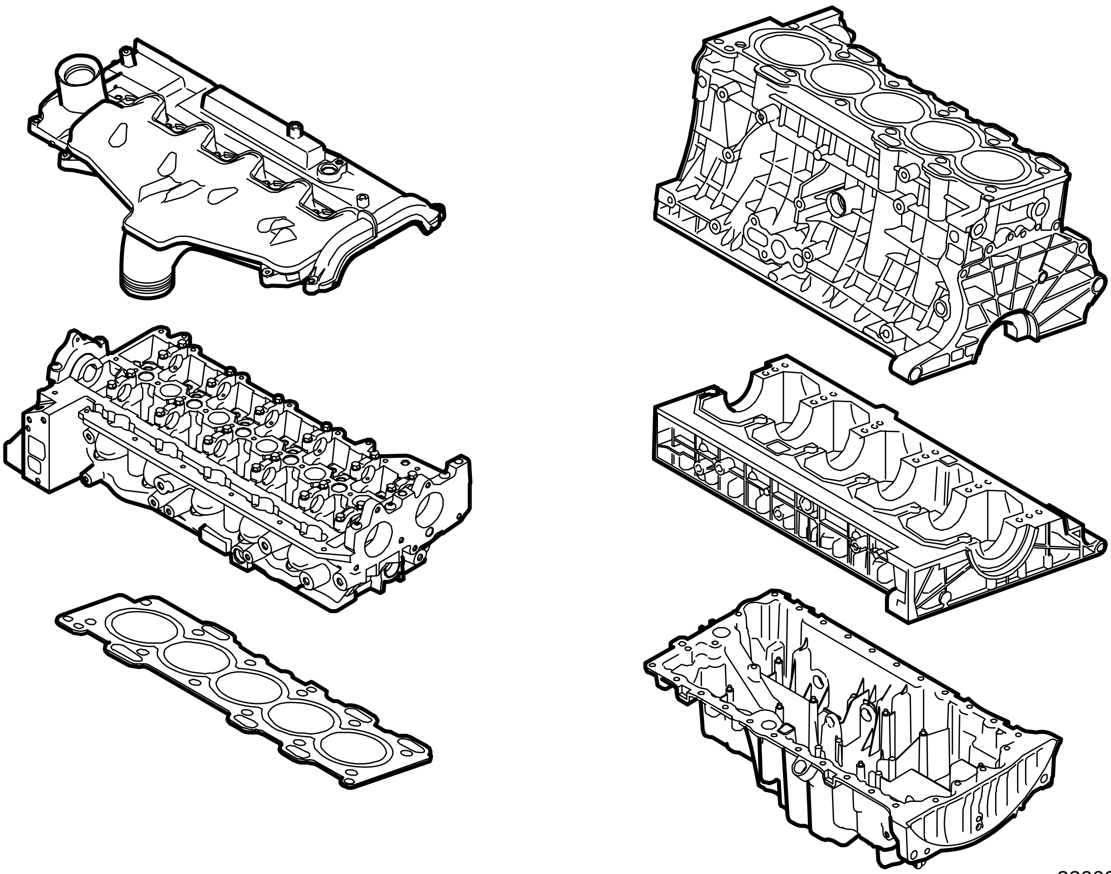
M66E/201</td></tr>
<tr><td colspan="2">Compression</td><td colspan="4">17,3:1</td></tr>
<tr><td colspan="2">Idling speed</td><td colspan="4">700 rpm</td></tr>
<tr><td colspan="2">Maximum engine speed</td><td colspan="4">4600 rpm</td></tr>
<tr><td colspan="2">Cetane</td><td colspan="4">48 minimum</td></tr>
</table>

Notes



2200325m

Engine body

Intake manifold/valve cover

- The intake manifold/valve cover is made of plastic.
- Modified ducts for improved air flow.
- O-ring type gasket.

Cylinder head

- Adapted for swirl throttle.
- The tangential ducts have greater volume for improved filling of the cylinders.
- The cylinder head gasket is available in different thicknesses to obtain the correct compression ratio. A certain thickness is equivalent to a certain specific marking.

Cylinder block

- Adapted with lugs, threads etc. to be able to accommodate new components.

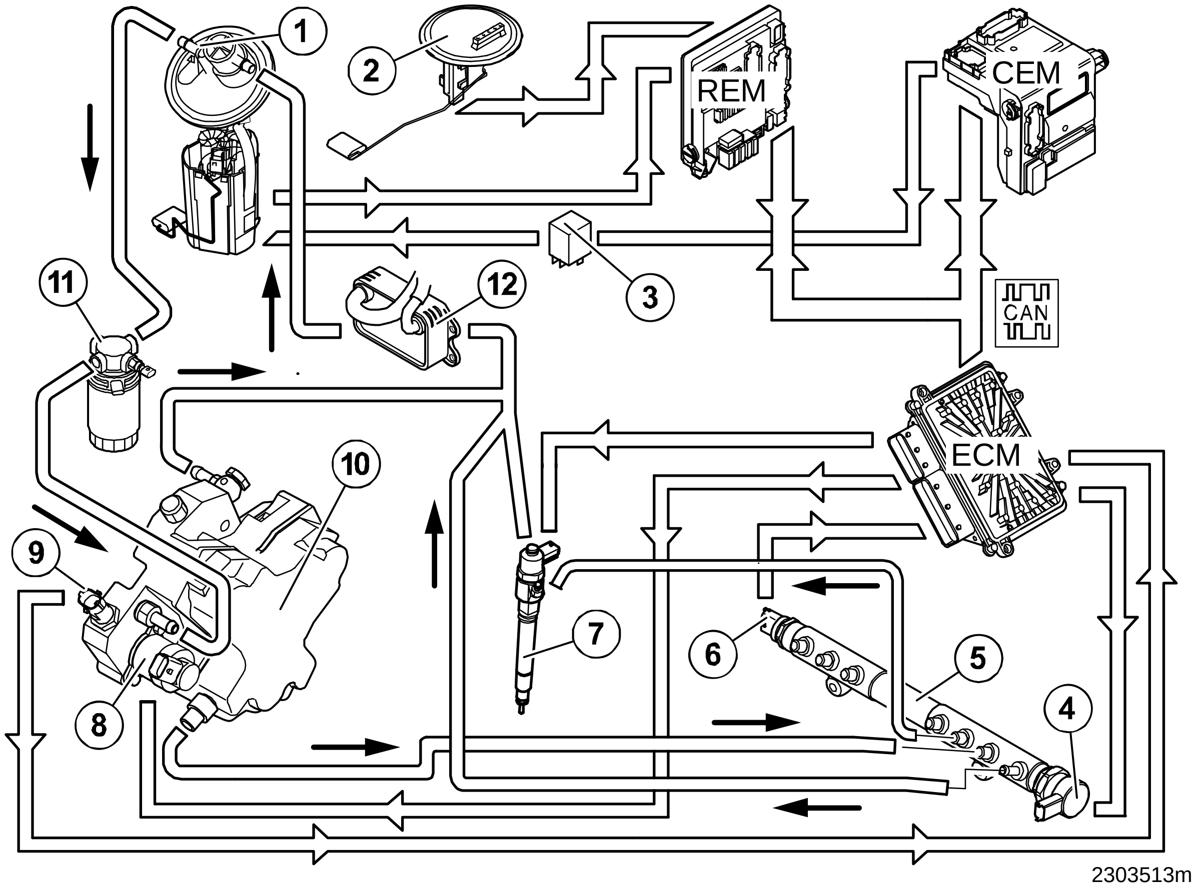
Intermediate section

- Reinforced with more ribs.

Oil sump

- Adapted for the combined oil level/oil temperature sensor.

Notes



1	Electrical fuel pump with fuel level sensor	7	Injector
2	Fuel level sensor	8	Fuel flow control valve
3	Relay, fuel pump	9	Fuel temperature sensor
4	Fuel pressure control valve	10	High pressure pump
5	Fuel rail	11	Fuel filter with preheating
6	Fuel pressure sensor	12	Fuel cooler (AWD only)

Fuel system

High pressure pump/electric fuel pump

The fuel system has undergone a number of modifications compared with the D5244T/T2.

The combined low/high pressure pump is replaced with just one high pressure pump. The drive is as for the D5244T/T2 i.e. via the intake camshaft. The high pressure pump has three pump elements as before.

Instead of having one low pressure pump integrated in the high pressure pump unit the existing electrical fuel pump is used, located in the saddle tank's right-hand saddle pocket

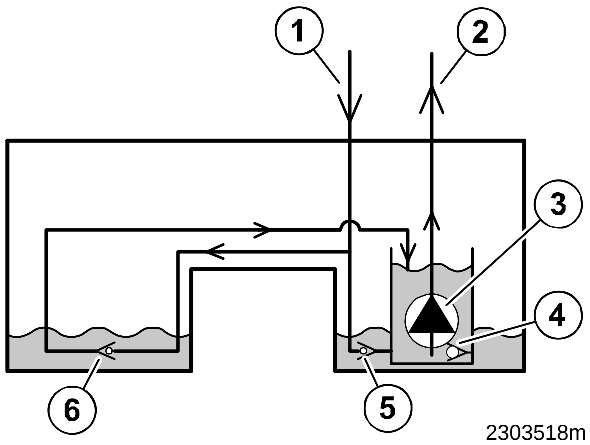
The electrical fuel pump is activated during the whole operating cycle. This means that the high pressure pump is continuously supplied with fuel at a constant pressure. Amongst other things this improves starting in excessive heat.

The pressure regulation takes place in the high pressure pump. The relative fuel pressure is 3.5 to 5.5 bar. The capacity is 150-180 litres per hour.

The pump works with constant (unregulated) speed and the supply voltage is equivalent to the car's system voltage.

When the key is turned from position 0 or I to position II the fuel pump is activated for a certain time.
- With more than 10 litres in the fuel tank the pump is activated for 10 seconds.
- With less than 10 litres the pump is activated for 45 seconds.
- In the event of unintentional stalling the pump is activated for a further 10 seconds.

Principle, fuel tank system



The electrical fuel pump (3) supplies the high pressure pump with fuel via the outlet line (2).

There is a safety valve in the electrical fuel pump that opens at approx. 7 bar.

The return fuel (1) drives both ejector pumps (5 and 6).

The left-hand ejector pump (6) moves fuel to the right-hand half of the tank while the right-hand ejector pump (2) fills the fuel pump reservoir.

(4) is a non-return valve that works as fuel inlet to the reservoir.

Injectors

The injectors have 7 holes (previously 5). They have also undergone a number of inner modifications for better sealing amongst other things.

The injectors are controlled up to an engine speed of approx. 3400 rpm and under normal conditions with a pilot injection and a main injection. Following which only a main injection takes place. The function is as before.

What is new is that during certain conditions two pilot injections are used. This takes place at low outside temperatures (lower than approx. +4°C) and at high altitude (over 1000 metres above sea level) at an engine speed up to approx. 2800 rpm. This provides a stable combustion with low combustion noise.
Only one pilot injection is used from 2800 rpm to 3400 rpm with no pilot injection at all at speeds above 3400 rpm.

Re-injection can also take place in one or two stages. A re-injection takes place for example at half load between approx. 1500-2500 rpm. This is to combust carbon during afterburning in the cylinder.

Two re-injections take place during regeneration. The first is used to increase the temperature before the catalytic converter. The second is used to heat up the exhaust gases when they pass through the catalytic converter so that the regeneration process can be initiated.

The injectors can be replaced individually.

NOTE: When replacing the injector(s) the ECM and Volvo's database must be updated. This is done using the function in VIDA! If this is not carried out then performance, fuel consumption and emissions are affected amongst other things!

Miscellaneous

- The non-return valve on the injectors' return side has been removed. The required counterpressure is reached "automatically" by means of the existing components on the fuel return side such as the ejector pumps and hoses for example.
- Modified geometrical design of the fuel rail (the rail).
- Delivery pipe with greater inner diameter. Results in decreased pressure pulses.
- A fuel pressure control valve is located on the fuel rail to enable faster regulation of the fuel pressure for the injectors. The valve is controlled by the ECM using a PWM signal.
  The functioning principle of the fuel pressure control valve is the same as the fuel pressure valve for the D4204T.
  (For further information see NCF 0338/0347, Engine D4204T).
- The fuel filter and the fuel heater are located under the car.
- By means of having a fuel temperature sensor that registers the temperature of the return fuel the ECM can compensate for the differences in density caused by temperature variations.

Notes

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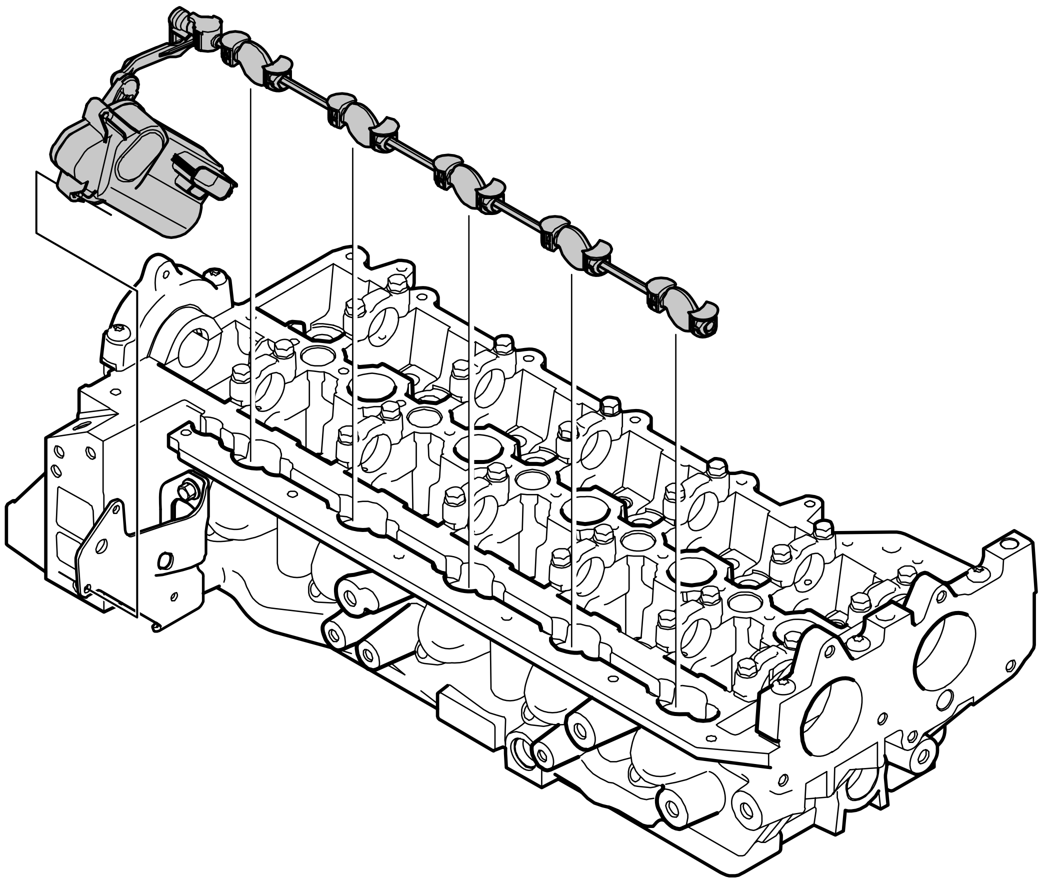


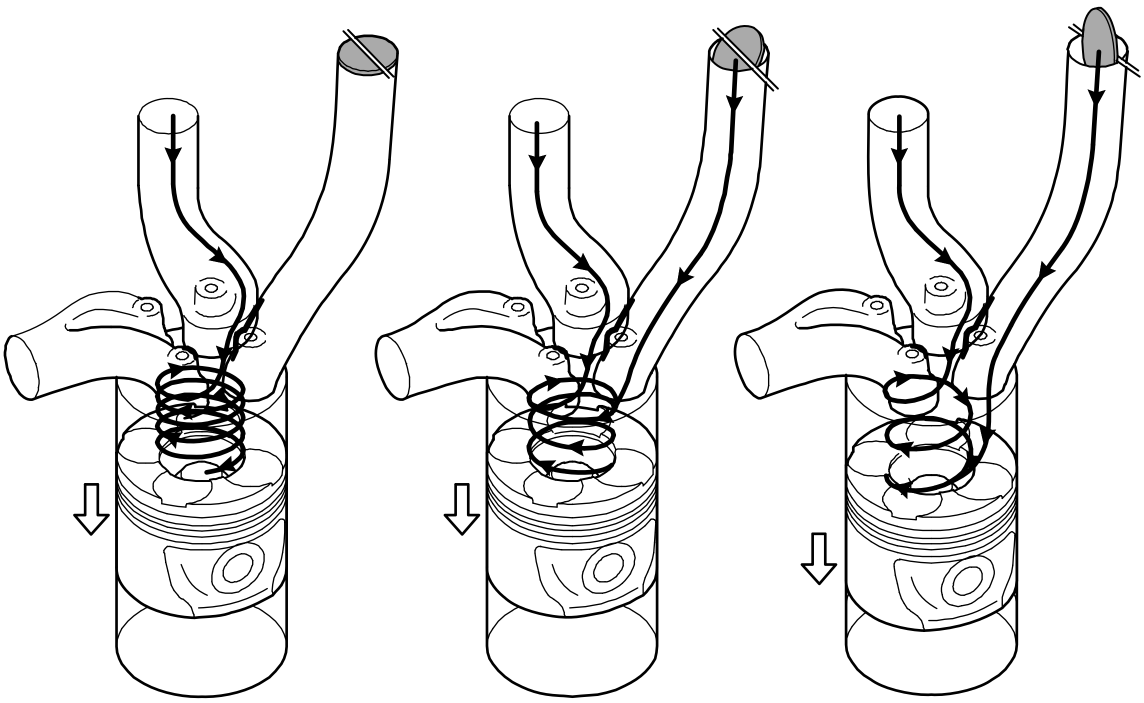
Components and functions

Swirl throttle

Exhaust gas recirculation (EGR) control is used to an even greater extent in order to comply with the emission requirements of EURO4 with regard to nitrogen oxide emissions, NOx etc. One set of the cylinder head's inlet ports, the tangential ducts, are equipped with a shutter, a so-called "swirl throttle", in order to improve the combustion process during exhaust gas recirculation (EGR) control. By closing the throttle the flow of air through the swirl ducts increases, which increases the swirl formation in the cylinder. This improves the mixture of air and fuel at low engine speeds. In this way the emissions from the cylinder in terms of unburned fuel and particles are reduced.

The principle is based on regulating the air volume passing through the tangential ducts.

By fully or partly closing the tangential ducts relatively more air will pass through the swirl ducts. With, for example, fully closed tangential ducts all air to the cylinders is forced to pass through the swirl ducts. This results in high air speed with an extremely powerful swirl formation. The injected fuel is distributed in the whole combustion chamber thanks to the swirl formation which means that excess fuel is minimised in certain areas. The combustion takes place efficiently which results in low emissions.



2303516m

The throttles are closed during idling and then open steplessly up to an engine speed of approx. 3000 rpm. At an engine speed above 3000 rpm the throttles are always open. They also open if the load is high despite the engine speed falling below 3000 rpm.

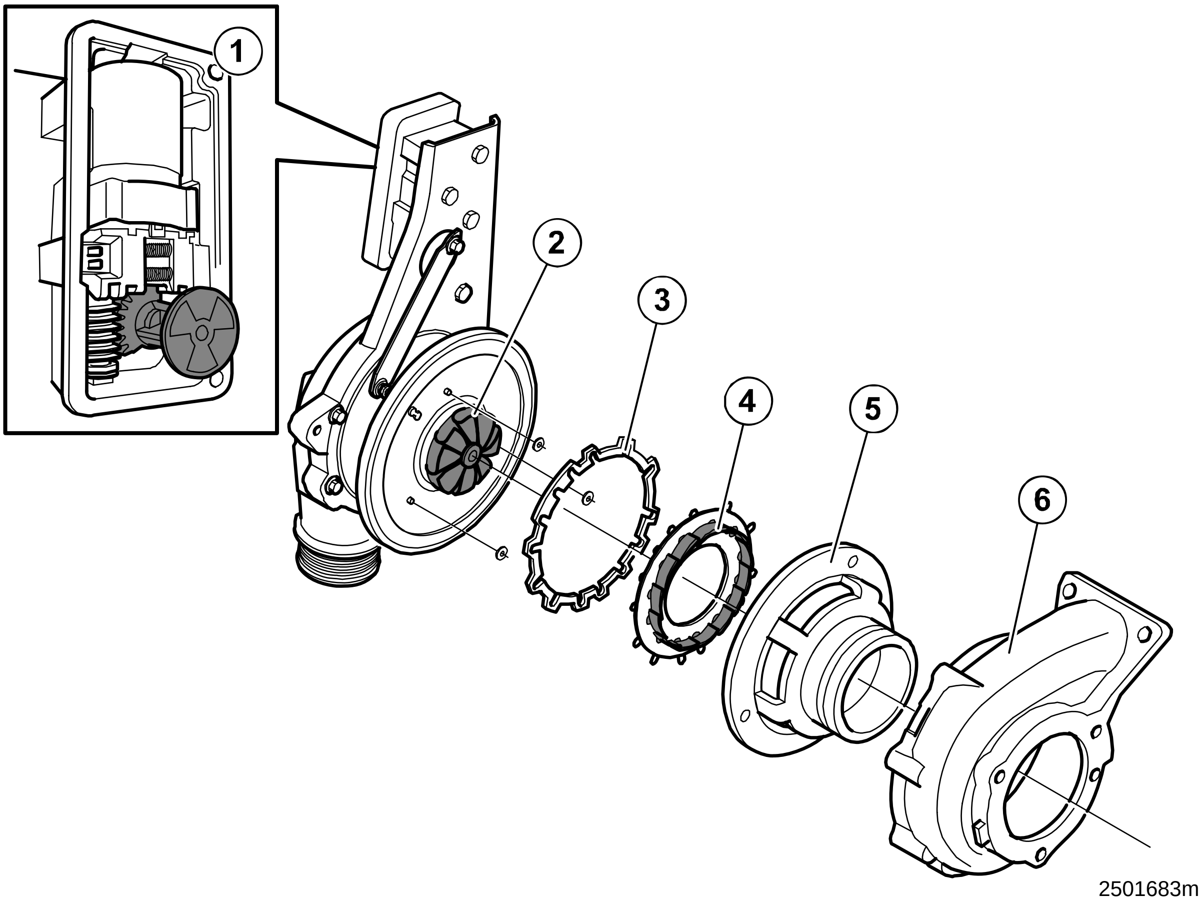
The position of the throttles is determined by the ECM based primarily on load and engine speed.

The position of the throttles is regulated by a direct current motor. The motor is directly controlled by the ECM by means of a PWM signal. When the throttles have reached the required position the design (worm gear) means that the position of the throttles is fixed (locked). The electric motor does not then need to be supplied with power.
The position of the motor and thereby the throttles is registered by a hall sensor. A voltage signal between approx. 0.3-4.7 volts is sent to the ECM where 4.7 volts is equivalent to a closed throttle.
By means of the feedback the ECM can determine if the actual position of the throttles corresponds to the required position. If this not the case then a diagnostic trouble code (DTC) is generated.

In order that the ECM shall know the position of the throttles and to be able to compensate for any wear in the internal components the throttle motor is operated to its mechanical stops (open/closed position) after a certain number of ignition switch-offs.

During normal operation the electric motor is controlled so that the end positions of the throttles do not reach a mechanical stop. This is to avoid loading the mechanism and electric motor unnecessarily.

The throttles are open when the motor is started.



1	Turbocharger control motor, REA (Rotor Electric Actuator)	4	Guide rails
2	Turbine	5	Housing for guide rails
3	Ring	6	Turbine housing

Turbocharger with REA (Rotor Electric Actuator) and VNT (Variable Nozzle Turbine)

The turbocharger has guide rails with gently curved design. The design results in improved flow to the turbine wheel and reduced pressure drop.

The compressor wheel has a diameter of 56 mm (the D5244T/T2 has 52 mm). The increased diameter, together with other modifications, means that the turbocharger can be used efficiently over a wider range of speed.

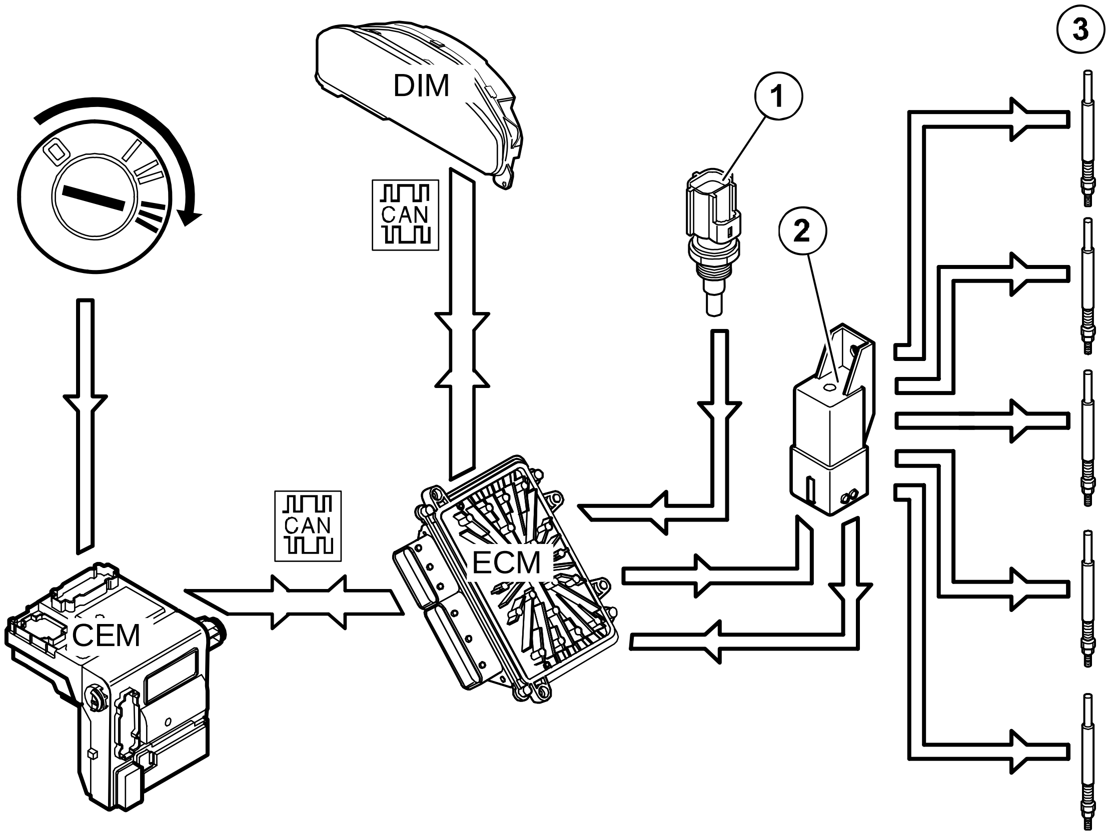
The position of the guide rails is regulated by the REA (Rotor Electric Actuator). The REA consists of an electric direct current motor with internal electronics. The ECM calculates the required position which corresponds to a PWM signal that is sent to the REA. The REA's internal electronic direct current motor, and thereby the position of the guide rails, is controlled based on the PWM signal.

A more precise position is obtained more quickly during regulation by means of electrically controlling the guide rails. The risk of overshoots in charge pressure due to the sluggishness in earlier pneumatic systems is eliminated.

REA electronics contain self-diagnosis. When the REA modulates the normal PWM signal based on its own status the ECM can register and interpret any faults. In the event of a fault related to the turbo control the ECM generates a diagnostic trouble code (DTC).
A charge pressure sensor signal is also used amongst other things for diagnosing the turbo control. If the actual charge pressure does not correspond with the required charge pressure then a diagnostic trouble code (DTC) is generated.

When the REA transfers the power through a worm gear the motor is without power when the guide rails have adopted the required position. The position is locked "automatically" by means of the design.

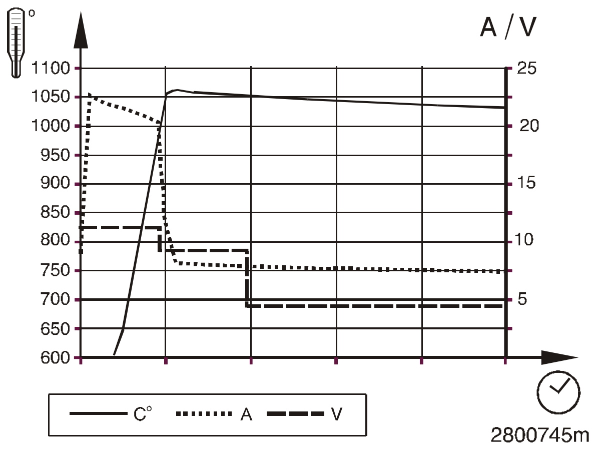
The turbocharger's bearing housing is cooled by coolant.
This results in efficient heat dissipation especially with the engine switched off and a hot turbocharger. When the engine is switched off the coolant circulates through the turbocharger on its own.



2800743m

1	Coolant temperature sensor.	2	Glow plug relay (control module)	3	Glow plug

Heating



2800745m

The glow plugs have a low inner resistance in order to obtain faster heating and consequently a rapid start of the engine and low emissions.

The glow plugs are designed for a continuous voltage of 4.4 volts.

Rapid heating is obtained by supplying the glow plugs with an "overvoltage" of 12 volts.
A temperature of approx. 1000°C is reached after approx. 3 seconds.

After the glow plugs have initially been supplied with power at 12 volts the voltage is reduced after approx. 1.5 seconds to approx. 9 volts.
After a further few tenths of a second the voltage is reduced further to a nominal 4.4 volts.

Control

The ECM calculates when/how the glow plugs should be supplied with power. The required voltage level is sent as a PWM signal to the glow plugs' relay/control module. In turn the glow plugs' relay/control module controls the glow plugs, also using a PWM signal.

The glow plugs' voltage level is controlled based primarily on engine speed, outside temperature, engine temperature, injection quantity (mass) and time.

Example:

Heating "Pre glow" and "Readiness"

When the ignition key is turned from position 0 or I to position II the glow plugs are activated for a maximum of 15 seconds if the outside temperature falls below + 5°C. Above + 5°C no heating is allowed. This temperature limit is however adapted to the current altitude. At an altitude of 3000 metres above sea level for example heating is permitted at an outside temperature of +20°C.

The first three seconds of the preheating period are indicated in the DIM and this is called "Pre glow".

After three seconds the heating changes over to a mode called "Readiness".

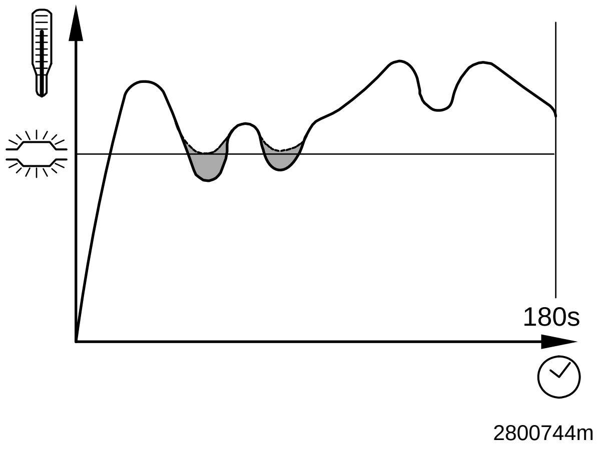
"Start glow" and afterglow "Post glow"

The glow plugs are also activated in ignition position III. The period is called "Start glow". Maximum time in this phase is 90 seconds.

When the engine has started the control of the glow plugs changes over to afterglow, the so-called "Post glow" mode.

Good starting properties are obtained by means of the glow plugs also being activated after the engine has started (i.e. reaching approx. 400 rpm = CAN signal "Engine running").
The temperature is initially 1000°C. After 15 seconds the temperature is lowered to 950°C. After a further 75 seconds the temperature is lowered to 850-900°C.

In "Post glow" the glow plugs are activated for a maximum of 180 seconds.



The graph depicts the principle for catalytic converter temperature after starting.

The shaded areas show temperature increases where "Cat light off" temperature is obtained thanks to activated glow plugs.

"Cat light off" = the lowest temperature the catalytic converter must have to work as a catalytic converter.

Several examples that affect the heating:

- No heating is allowed if the engine temperature exceeds +30°C.
- "Post glow" is calibrated for different environments and continues for a maximum of 180 seconds. Included in the calculated time are parameters such as coolant temperature, outside temperature and altitude.
- The heating is switched off at an engine speed above 4000 rpm. If the engine speed decreases then heating is resumed. The period for which the glow plugs were not activated is also included in the total glow duration.
- If the injected quantity exceeds 50 mg per operating cycle and cylinder then the heating is temporarily halted. (Full load is approx. 65 mg). If the injected quantity returns to below 50 mg then heating is resumed. The period for which the glow plugs were not activated is also included in the total glow duration.
- Irrespective of the glow duration, the glow plugs' relay/control module compensates for voltage variations during heating, both high and low voltages. This is so that the glow plugs shall always work with the correct output. The glow plugs have full functionality down to 8 volts and limited functionality from 8 volts down to 6 volts.
- There is a function in the engine control module (ECM) that calculates the amount of energy in the glow plugs during "Pre glow".
  When heating is interrupted and then resumed after a short time then the amount of energy supplied is adapted so that the glow plugs attain the required energy.
  This is to prevent the plugs from being supplied with a too high voltage and thereby reaching too high temperatures. (The glow plugs can manage 1130°C and are destroyed at approx. 1200°C).
  By calculating how much the temperature of the plugs has fallen during the shutdown period the supply voltage is adapted so that the temperature of the plugs does not become too high.
- During regeneration the glow plugs are activated with a small load for example. By increasing the engine's load the temperature of the exhaust gases also increases which is necessary to obtain a correct regeneration process.

Glow plug relay/control module for glow plugs

The relay/control module for glow plugs contains powerful transistors (MOSFET) which each supply their own glow plug. There is a shunt for each glow plug that is used to diagnose the plugs in the event of short circuit and open circuit. Any diagnostic trouble codes (DTC) are sent to the ECM where they are stored.

NOTE: The glow plugs must be connected directly to a maximum 4.4 volts. If the plugs are connected to a higher voltage then they could be destroyed.

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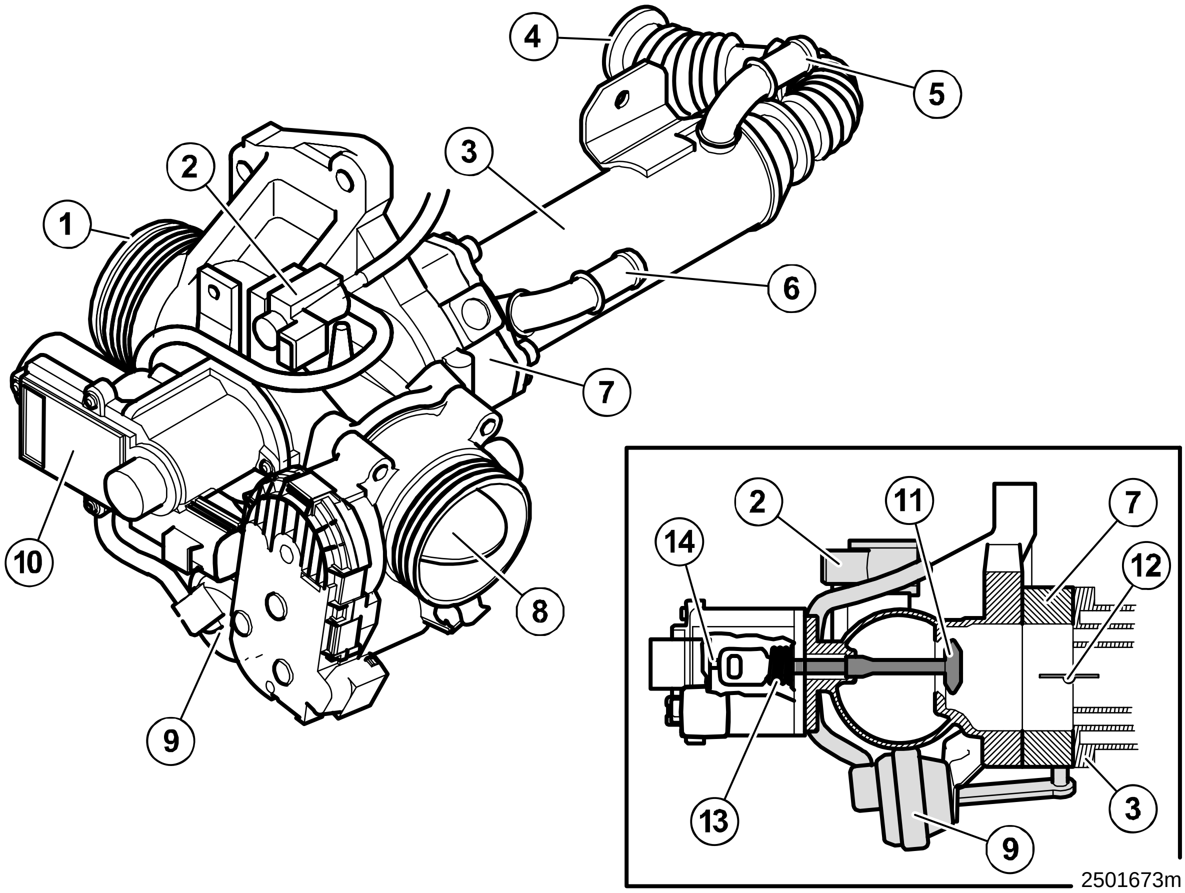


Coolant cooled EGR (Exhaust Gas Recirculation)

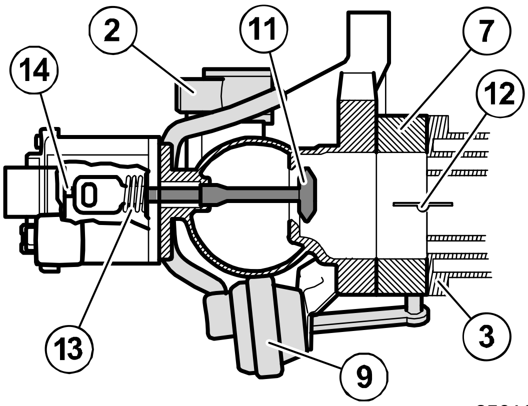
1	To intake manifold	8	Throttle body ETA (Electronic Throttle Actuator)
2	Electrical valve/solenoid (only applies to cars with manual gearbox)	9	Vacuum box (only applies to cars with manual gearbox)
3	Exhaust gas recirculation (EGR) cooler	10	Control motor unit
4	Exhaust gas inlet to exhaust gas recirculation (EGR) cooler	11	Exhaust gas recirculation (EGR) valve
5	Coolant outlet	12	Bypass valve
6	Coolant inlet	13	Return spring
7	Housing with bypass valve (bypass valve only applies to cars with manual gearbox)	14	Position sensor (hall sensor)

Exhaust gas recirculation (EGR) system

Modifications compared with the D5244T/T2 are:

- The control motor unit with exhaust gas recirculation (EGR) valve is located on the exhaust gas recirculation (EGR) cooler cold side i.e. in direct connection with the intake manifold. This results in a higher exhaust gas recirculation (EGR) flow with improved cooling. A temperature reduction of up to 200°C can be achieved.
- The valve that regulates the exhaust gas recirculation (EGR) flow has only one valve disc (previously two).
- The position of the valve is controlled by a direct current motor (previously solenoid).
- The coolant flows against the exhaust gases (previously with them) for more efficient cooling.
  The pipes through which the exhaust gases pass are of a modified design. They are now round with spiral shape, for improved cooling capacity.

Control motor unit



2501682m

The control motor unit consists of a direct current motor and position sensor (14) and electronics.

The ECM calculates the timing and the volume of exhaust gases to be recirculated.

The volume of exhaust gases recirculated corresponds to a PWM signal that is sent to the electric motor's electronics.

In turn the electronics control how much the electric motor shall rotate which results in a certain opening of the valve.

The direct current motor does not affect the exhaust gas recirculation (EGR) valve (11) directly.
During regulation the motor is operated in both directions.

In the event of any fault the motor returns the valve to the starting position, closed position, using the spring (13).

The opening movement of the valve is registered by a hall sensor (14). The movement/position is evaluated by the internal electronics. Following evaluation the status is sent continuously as a PWM signal to the ECM. If the required position does not correspond with the actual position then a diagnostic trouble code (DTC) is generated in the ECM.

Regulation

In order to reduce NOx, recirculation of the exhaust gases is used to a greater extent than previously. The recirculation is greatest at part load down to low load at engine speeds from approx. 2500 rpm down to idling.
In the event of a major load the exhaust gas recirculation (EGR) valve closes in principle for the whole speed range.

During float driving in a high gear the exhaust gas recirculation can take place up to engine speeds corresponding to a vehicle speed of approx. 150-160 km/h.

Exhaust gas recirculation (EGR) control is in principle allowed when:

- The temperature of the intake air is between approx. + 4°C and + 40°C. The temperature is registered by the temperature sensor located in the MAF sensor's housing.
- The temperature of the coolant is between approx. +5°C and +105°C.
- Up to an altitude of 1000 metres above sea level.

Exhaust gas recirculation (EGR) control is stopped for example:

- When the temperature of the intake air is lower than approx. +4°C. This is to prevent ice forming where exhaust gases meet fresh air.
- At high temperatures. To prevent overheating resulting in engine damage.
- At an altitude higher than 1000 metres above seal level. In order that sufficient oxygen is available for the combustion.
- When idling has been longer than a couple of minutes. Exhaust gas recirculation (EGR) control is stopped to prevent carbon deposits on the valve and ducts. If the accelerator pedal is activated when exhaust gas recirculation (EGR) control is stopped then the system resumes normal exhaust gas recirculation (EGR) control.

To enable further fine adjustment of exhaust gas recirculation (EGR) control, the ECM uses the following components:

- Throttle unit ETA (Electronic Throttle Actuator). If the air volume registered by the MAF sensor deviates from the required volume then the ECM adapts the position of the throttle. By reducing or opening the flow area for incoming air the mixture of fresh air/recirculated exhaust gases can be fine-tuned so that the required ratio is achieved.
- Turbocharger guide rail control. The pressure in the intake manifold acts on the volume of exhaust gases that is recirculated. The ECM exerts control so that the pressure for each situation reaches the required value which contributes to the correct volume of exhaust gases being recirculated amongst other things.

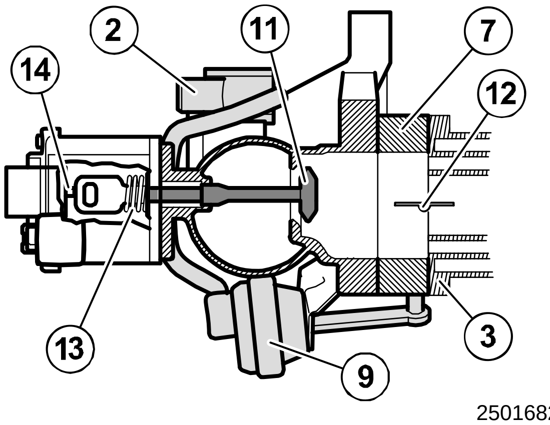
Purpose of the lambda-sond

- By having a lambda-sond located before the catalytic converter the ECM can determine whether sufficient oxygen has been supplied for combustion. Too little oxygen results in poor combustion with carbon emissions, major HC emissions and the resulting smoke.
  By means of the lambda-sond signal the ECM can compensate for deviation in the injectors and the MAF sensor's signals.
  Deviation = slightly changed signal despite the same conditions.
- The deviation is compensated for by means of a different control of charge pressure (through REA) and air volume (through EGR).

Exhaust gas recirculation (EGR) cooler

The exhaust gas recirculation (EGR) cooler is available in two versions, with bypass valve and without.

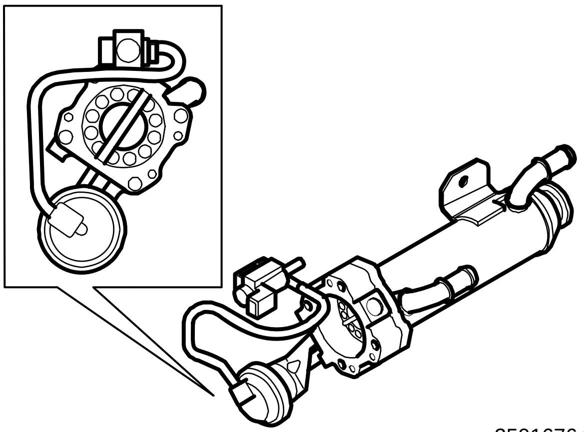
Cooler with bypass valve



2501682m

The cooler with bypass valve has a centrally located pipe with large diameter through which the exhaust gases pass when the valve is open.
A housing (7) with a valve (12) is located between the cooler and the exhaust gas recirculation (EGR) valve.

An electric valve is (2) controlled by the ECM by means of a PWM signal.
In turn the valve directs atmospheric pressure or vacuum through a hose to a vacuum box (9).
In turn the vacuum box diaphragm is in connection with the valve (12) by means of links.
If atmospheric pressure prevails in the box then valve is closed while a vacuum means that the valve opens.



2501676m

The open/closed position of the valve is calculated by the ECM based primarily on load and coolant temperature.

During the engine's warm-up phase the valve is open for the first few minutes and then starts to alternate between open and closed. The valve is closed in an engine at operating temperature.

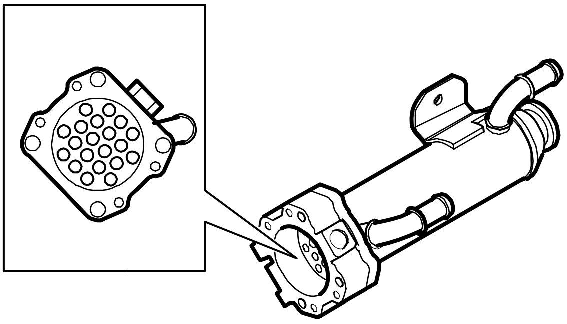
When the valve is open the exhaust gas recirculation (EGR) gases are directed to the combustion chamber with less cooling.

The hot recirculated exhaust gases speed up the heating of the engine which in turn results in reduced emissions.

The ECM can only diagnose electrical faults regarding the vacuum valve.

The bypass valve is used on all cars with manual gearbox.

Cooler without bypass valve



2501677m

The cooler without bypass valve only has a housing and consequently has no valve.
The centrally located pipe is equipped with a number of pipes.
"All" recirculated exhaust gases are cooled.

The system is used on cars with automatic gearbox.

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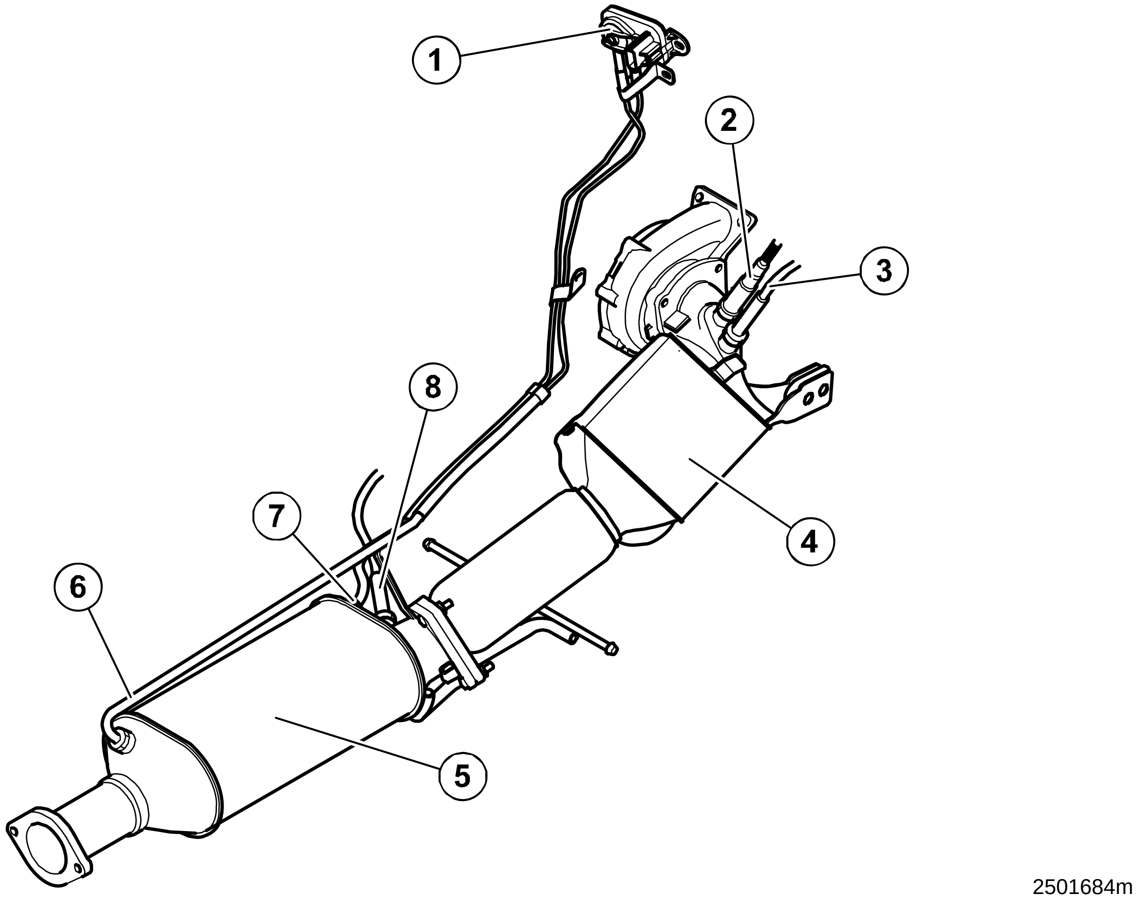


1	Differential pressure sensor	5	Particle filter
2	Lambda-sond	5	Pipe
3	Temperature sensor, catalytic converter	6	Pipe
4	Catalytic converter	8	Temperature sensor, particle filter

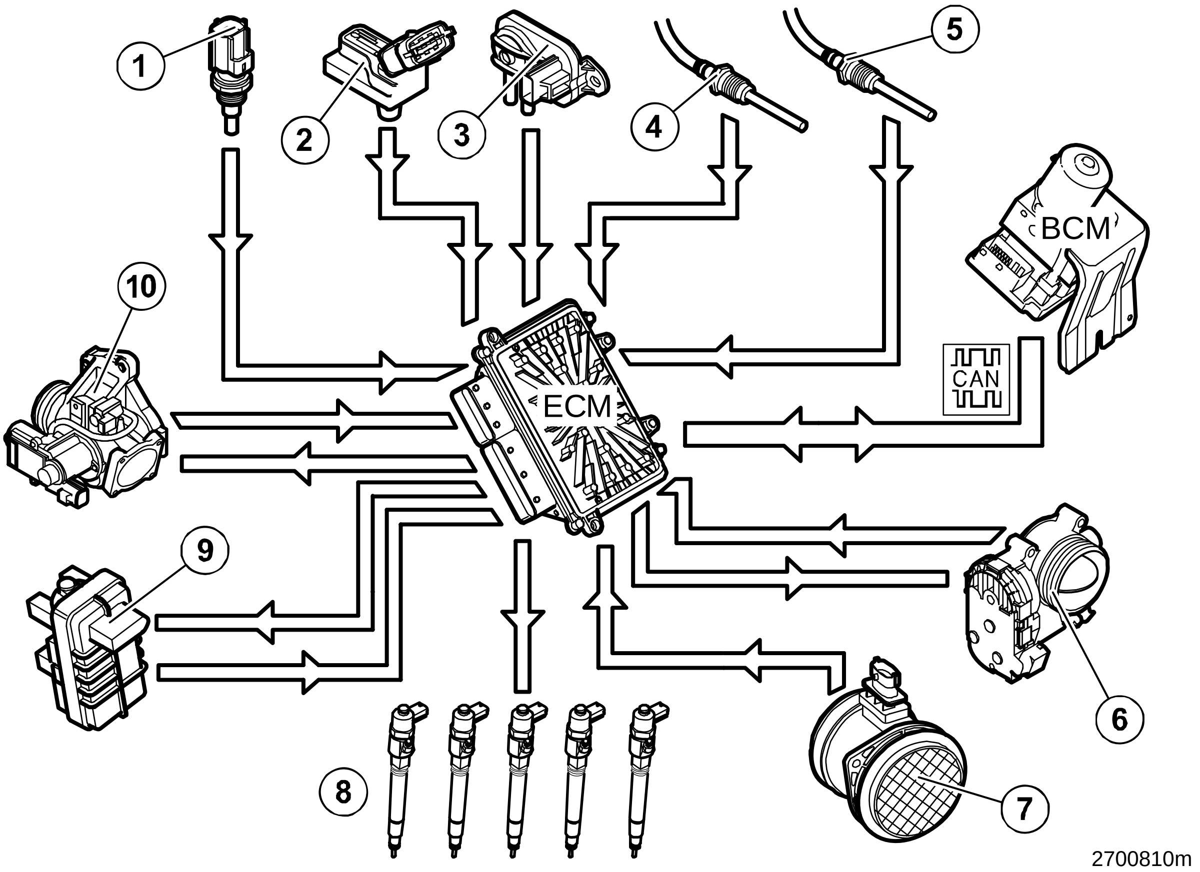
Particle filter

The engines are equipped with a system called cDPF (catalyst Diesel Particulate Filter).
The unit works partly as a particle filter and partly as an oxidation catalytic converter. This means that the emissions of particles as well as HC and CO are reduced.

The particle filter is made of porous silicon carbide coated with a washcoat (surface enlarger). The washcoat in turn is coated with a layer of precious metal. The precious metal works as a catalyst and oxidises CO and HC to CO_2 and water.
The particle filter section works for example as for the D4204T. I.e. the exhaust gases are forced through the filter's porous walls at which the particles attach to the walls.
A new filter traps approx. 70% of the particles, and a "slightly" used one more than 95% of the particles.

Burning clean the filter takes place without any additives.

The particle filter has no replacement interval.



1	Coolant temperature sensor.	6	Throttle unit, ETA
2	Charge pressure sensor	7	Mass air flow sensor, MAF
3	Differential pressure sensor	8	Injectors
4	Temperature sensor, catalytic converter	9	Turbocharger control motor, REA
5	Temperature sensor, particle filter	10	EGR

Regeneration

The particles that are trapped in the filter must be burned away regularly. The distance between each regeneration is approx. 500 to 1000 km.

Temperature

The required temperature during regeneration is approx. +600°C for exhaust gases in the filter.

When the exhaust gases to the filter during normal operation have a temperature of between +100°C (small load) and +650°C (full load) the ECM regulates air flow and fuel injection amongst other things so that a temperature of approx. 600°C is obtained.

When regeneration is required

The ECM calculates when regeneration is required.

In principle regeneration should be initiated when a certain volume of particles is trapped in the filter. A guideline value is approx. 30 grams. Depending on circumstances (driving style, temperatures etc.) regeneration can also take place at other values.
Main factors governing when regeneration is required are:

- Distance/fuel consumed since last regeneration. A "normal" distance is approx. 800 km or approx. 80 litres of fuel consumed. Everything depends on the driving conditions.
- Estimated volume of particles in the filter. Based mainly on driving conditions (temperature, load, fuel consumption etc.) since last regeneration.
- Estimated volume of ash in the filter. Based mainly on distance.
- The pressure drop over the filter. The pressure drop is measured by a differential pressure sensor that measures and compares the pressure before and after the filter. A "cleaned" filter has a pressure drop of approx. 5hPa - 20 hPa. At the time for regeneration the pressure drop is approx. 100 hPa.
  The differential pressure is also used for diagnosing leakage for example (small pressure drop) and clogged filter (large pressure drop).

"Normal" regeneration

Based on coolant temperature and the exhaust temperature at both the catalytic converter inlet and the particle filter inlet the ECM judges whether regeneration should be initiated.

If the conditions are right then the ECM takes a number of actions. For example:

- The exhaust gas recirculation (EGR) valve is closed.
- The fuel pressure is decreased.
- The charge pressure is decreased.
- The ECM controls the throttle for ETA so that the incoming air volume is adapted (primarily reduced).
  The injectors are activated twice more after the main injection.
  - The first re-injection is primarily used to increase the temperature before the catalytic converter (from approx. 150° to approx. 300°).
  - The second re-injection is used to increase the temperature of the exhaust gases when they pass through the catalytic converter. When the heated exhaust gases (approx. 600°) reach the particle filter, regeneration starts.
    During this injection the fuel is injected into the cylinder and vaporised. When the exhaust valves are open the vaporised fuel follows the exhaust gases on to the catalytic converter where they are ignited. The heated gases continue on to the particle filter which is heated, at which the regeneration process starts.
- By means of the ECM registering amongst other things the exhaust temperature, incoming air volume (oxygen volume) and injected fuel during the entire process, the ECM can determine whether regeneration has succeeded and with it reset the "counter". Normally this takes approx. 10 - 30 minutes.
  If the process is prematurely interrupted for example due to the operating cycle being stopped (the driver switches off the engine) the regeneration process is resumed as soon as the conditions for initiation are fulfilled. The internal counter adds up the number of particles added from when the regeneration was interrupted to when it is started.
- On the occasions when regeneration is required but the conditions for initiation are not fulfilled the driver is advised by means of a text message in the DIM to drive the car in such a way that the initiation conditions are fulfilled.

"Favourable" regeneration

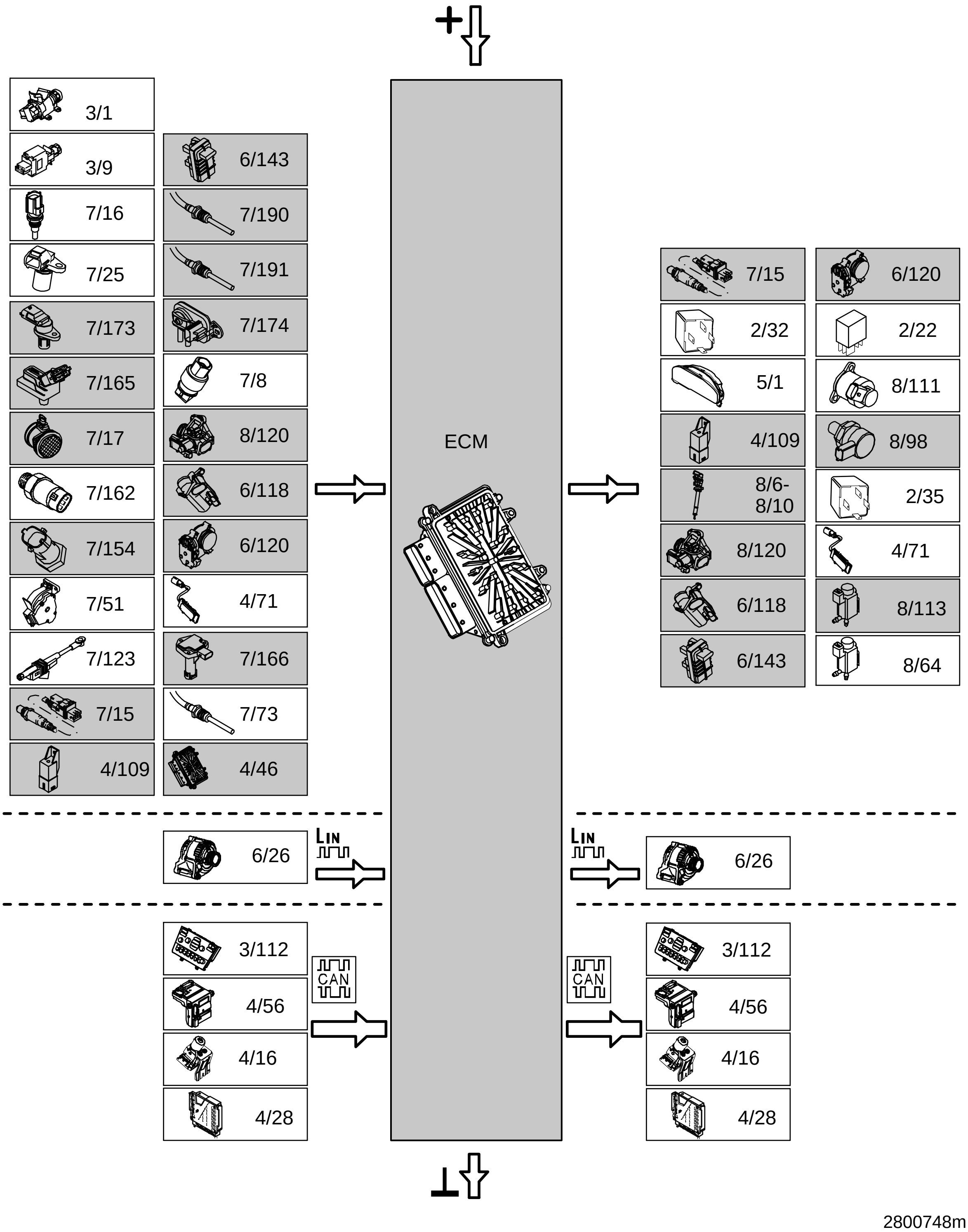
Under certain conditions regeneration is initiated when a particle volume is approx. 15 grams against a "normal" approx. 30 grams. This takes place at a uniform speed over approx. 85 km/h. The ECM controls the process as with "normal" regeneration.

"Spontaneous" regeneration

At major load and high engine speed the temperature in the particle filter can become so hot that regeneration starts spontaneously.

Then the ECM receives information by means of the temperature sensor before the particle filter amongst other things that spontaneous regeneration is underway and for how long it is taking place. The ECM uses this information to calculate when the next regeneration should be initiated.

Overview of modified components/signals



The shading marks new/modified component.

Directly connected input signals

New/modified component/sensor compared with D5244T/T2

Camshaft position (CMP) sensor (7/173), (changed)	Modified signal characteristics. The ratio between high and low signal is changed.
Air temperature and pressure sensor inlet (boost pressure sensor) (7/165), (changed)	Change of location. Now on the charge air cooler (CAC).
Mass air flow (MAF) sensor with integrated air temperature sensor (7/17), (changed)	Changed signal characteristics. The values for mass and temperature are sent as two separate digital signals.
Fuel temperature sensor (7/154), (new)	The signal allows the ECM to compensate for the density of the fuel.
Lambda-sond (7/15), (new)	Used for more precise exhaust gas recirculation (EGR) control. The signal is linear.
Glow plug relay/control module glow plug (4/109), (new)	The signal is used to diagnose the glow plugs.
Turbocharger control motor, REA (6/143), (new)	Provides information on the status of the control of the turbo's guide rails.
Temperature sensor, catalytic converter (7/190), (new)	The signal is used to control regeneration.
Temperature sensor, particle filter (7/191), (new)	The signal is used to control regeneration.
Differential pressure sensor, particle filter (7/174), (new)	The signal is used to control regeneration.
EGR with position sensor (8/120), (new)	Provides information on the position of the exhaust gas recirculation (EGR) valve.
Control motor, swirl duct throttle (6/118), (new)	Provides information on the position of the throttles by means of the position sensor.
Throttle unit, ETA (6/120), (new)	Provides information on the position of the throttle. Only one feedback signal is used.
Oil level sensor (7/166), (new)	Used for the first time on a diesel engine. Both temperature and level signal are used.
ECM (4/46) (new)	New ECM with greater capacity. Contains atmospheric pressure sensor and temperature sensor.

Unchanged component/sensor compared with D5244T/T2

Ignition switch (3/1)	Position sensor, accelerator pedal APM (7/51)	Alternator (6/26)
Brake lamp switch (3/9)	Position sensor, clutch pedal (7/123)	CCM (3/112)
Sensor, coolant temperature (7/16)	Pressure sensor AC (7/8)	CEM (4/56)
Engine speed (RPM) sensor, crankshaft (7/25)	Electronic fan control module, EFCM (4/71)	BCM (4/16)
Fuel pressure sensor (7/162)	Sensor, coolant level (7/73)	TCM (4/28) Introduced later.

Directly connected output signals

New/modified component/sensor compared with D5244T/T2

Lambda-sond (7/15), (new)	Heating the sond
Glow plug relay/control module glow plug (4/109), (new)	Control of glow plug temperature takes place via the glow plugs' relay/control module.
Injectors (8/6-8/10), (changed)	Injection takes place through pilot injection, main injection and re-injection depending on operating situation.
Exhaust gas recirculation (EGR) valve with position sensor (8/120), (new)	An electric motor controls the position of the exhaust gas recirculation (EGR) valve.
Control motor, swirl duct throttle (6/118), (new)	An electric motor controls the position of the throttles.
Turbocharger control motor (6/143), (new)	An electric motor controls the position of the guide rails. Provides more precise and rapid control of the turbocharger's guide rails.
Throttle unit, ETA, inlet (6/120), (new)	An electric motor controls the position of the throttle.
Fuel pressure control valve (8/98), (new)	The valve controls (lowers) the pressure in the fuel rail.
Bypass valve, exhaust gas recirculation (EGR) cooling (8/113), (new)	An electrical valve regulates the pressure in a vacuum box. The pressure in the box determines the position of the valve.

Unchanged component/sensor compared with D5244T/T2

Main relay, engine management system (2/32)	Relay, starter motor (2/35)	CCM (3/112)
Driver information module (DIM) (5/1)	Electronic fan control module, EFCM (4/71)	CEM (4/56)
Relay, AC compressor (2/22)	Solenoid valve, engine pads (8/64)	BCM (4/16)
Fuel flow control valve (8/111)	Alternator (6/26)	TCM (4/28) Introduced later.

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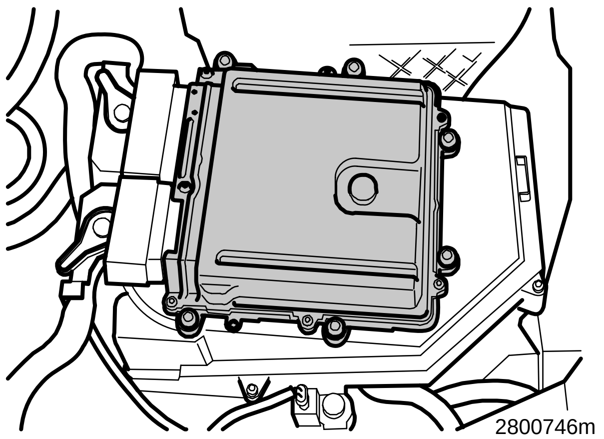
Component description

ECM, Engine management system, Bosch EDC16



Due to the introduction of new regulations and components an ECM with greater capacity is used.

Misc. data:

- Silver Oak processor MPC 562.
- EEPROM 4k x 8 bit.
- RAM 32k x 8 bit.
- Flash memory 512k x 32 bit (16 Mbit).

Contains a PTC type temperature sensor
and a piezoresistive pressure sensor.

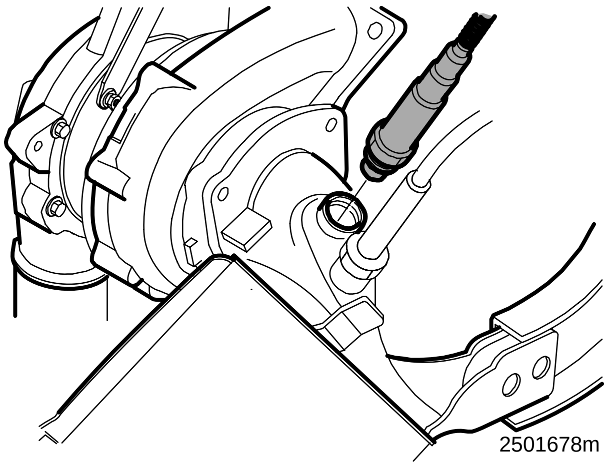
The control module is located on the air cleaner (ACL) housing.

The adapter for the breakout box is tool number 951 2902 (i.e. the same as for the B8444S for example).

The injectors' opening voltage of approx. 50 volts is generated internally in the control module.

During short opening sequences, tenths of a millisecond, the current is approx. 18 amperes. During longer sequences such as 0.6 to 0.8 milliseconds the current is regulated initially from the 18 amperes down to approx. 12 amperes.

Lambda-sond



The lambda-sond is linear and the broadband type. The signal to the ECM is:

- -1.1 mA at lambda 0.8
- 0 mA at lambda 1
- 0.94 mA at lambda 1.7
- 2.49 mA with pure air (e.g. at fuel shut-off)

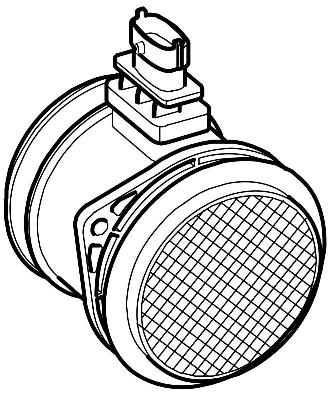
The trim resistor is located in the connector.

The reference air is created internally in the sond itself. Consequently no further inlet of reference air is required

The lambda-sond is primarily used at exhaust gas recirculation (EGR) control for control of the supply of air during the combustion process.

Diagnosis and diagnostic trouble codes (DTC) managed by the ECM.

MAF, mass air flow sensor



2501674m

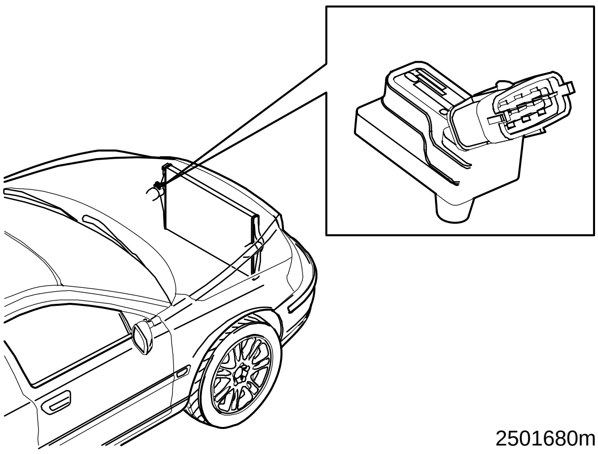
Mass air flow sensor with new signal characteristics. It also has narrower tolerances compared with earlier versions.

The mass air flow sensor's signals are created in accordance with earlier principles i.e. the mass air flow sensor is registered by means of warm film type sensors and the temperature of the incoming air by an NTC sensor. The values of the incoming air volume and the temperature of the incoming are sent as two separate digital signals to the ECM.

The MAF sensor's signal is used by the ECM to control the balance between exhaust gases and fresh air during the exhaust gas recirculation (EGR) control.

Diagnosis and diagnostic trouble codes (DTC) managed by the ECM.

TMAP (Temperature & Manifold Absolute Pressure) sensor



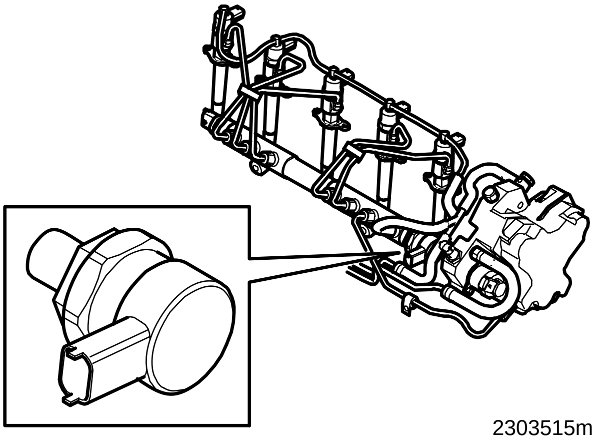
2501680m

Change of location. Registers temperature and pressure in the charge air cooler (CAC) outlet.

Piezoresistive pressure sensor.
The signal is used to regulate the charge pressure.

NTC type temperature sensor.
The signal is used to correct injection parameters.

Fuel pressure control valve located in the fuel rail



2303515m

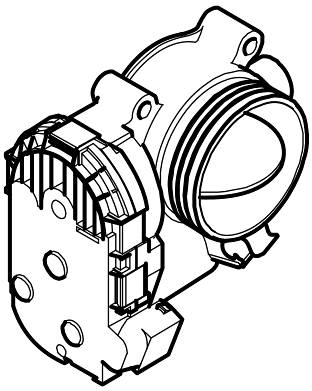
The valve fine-tunes the fuel pressure by means of pressure reduction.

The required pressure is obtained by means of returning excess fuel to the fuel tank.
The function is primarily used during cold starting when the fuel flow control valve is fully open.
In other areas the pressure is regulated by means of the fuel flow control valve.

The valve is kept without power by means of a spring at a certain initial pressure.

The valve is controlled by the ECM by means of a PWM signal.

ETA (Electronic Throttle Actuator)



2501681m

ETA works in accordance with the same functioning principle for the petrol engines. The primary differences are:

- Only one feedback signal to the ECM for throttle position
- Throttle diameter 57 mm against 64 mm for petrol engines.
- Only one return spring for the throttle. The starting position (default) is open.
  The Limp Home spring (as for petrol engines) is not required.

Function

The position of the throttle is regulated by a direct current motor. The ECM controls the motor by means of a PWM signal.

When the engine is switched off the throttle is closed instantaneously to enable a smooth stop. Following which the throttle returns to open position.

The throttle movement is registered by a potentiometer whose voltage signal is sent to the ECM.
The voltage is approx. 4.2V with open throttle to gradually fall to approx. 0.3V with closed throttle.
Only one feedback signal is used. (Two for petrol).

ETA is primarily used during exhaust gas recirculation (EGR) control, during regeneration of the particle filter and when the engine is switched off.

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Volvo Car Corporation